10/522375
DT05 Rec'd PCT/PTO 18 JAN 2005

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to freewheel bearings, in particular sprung freewheel bearings.

2. Description of the Relevant Art

Freewheel bearing devices include two elements that can rotate concentrically relative to one another in freewheel mode. The two elements transmit a torque without relative movement between the two elements when the device operates in torque take-up mode.

In sprung freewheel devices, a helical spring usually performs the freewheel function. The helical spring is fixed by one of its ends to one of the two elements of the device. In one relative direction of rotation between the two elements, the helical spring rubs without binding on a cylindrical bearing surface of the other element. When the relative movement between the two elements is reversed, the rubbing portion of the helical spring binds on the cylindrical bearing surface. The helical spring may be bound by the diametral expansion of the helical spring by the unwinding effect in a cylindrical bearing surface of a housing or by the winding effect on the cylindrical bearing surface of a shaft.

Freewheel devices may be used in alternator pulleys to inhibit the transmission of acyclicalities of an engine to the alternator, particularly via a belt. Being able to temporarily decouple an alternator from an engine, may inhibit the alternator from becoming the driver and causing a belt voltage reversal when for example there is a sudden drop in engine speed. This may spare the transmission belt, which enables its service life to be significantly increased.

WO A 98/50 709 entitled "SERPENTINE DRIVE SYSTEM WITH IMPROVED OVER-RUNNING ALTERNATOR DECOUPLER" and US 5,598,913 entitled "ONE-WAY OVER-RUNNING CLUTCH PULLEY" describe a drive system and a pulley system. The bearing function is performed by one or more antifriction bearings or rolling bearings and the freewheel function is performed by a helical spring one end of which is interlocked with a

piece connected to an inner rotating portion and a certain number of coils of which interact with the cylindrical bore of an outer piece in order to transmit a torque or no torque between the inner and outer pieces depending on the relative direction of rotation between those two pieces.

Such devices still have certain disadvantages. When the device is freewheeling, a number of coils of the spring rub in the outer piece with a relatively high speed equal to the differential angular speed between the two pieces, for example between the pulley and the hub. This may lead to rapid wear of the spring and undesirable failures of the device.

SUMMARY

Herein we describe a freewheel bearing device that may increase the service life of freewheel bearings. The device may reduce wear on freewheel bearings. In some embodiments, a freewheel bearing device may include a rolling bearing and a freewheel. A rolling bearing may include a plurality of rolling elements and a cage. The cage may retain the rolling elements. A freewheel may include a spring. A spring may include a first end, a second end, and/or a radial central portion. A radial central portion may interact with the cage. A end of the spring may interact with an element, such as an outer element and/or an inner element (e.g., an outer support, a shaft, etc.). Elements, such as an outer and/or inner element (e.g., an outer support or shaft) may be directly or indirectly interlocked with a body on which the rolling elements run.

In some embodiments, the sliding speed of the spring relative to the cage or to an element (e.g., an inner or outer element, such as an outer support or shaft) may be limited to approximately half the rotation speed of the bearing. Limiting the sliding speed of the spring may reduce wear of the spring and the piece the spring contacts when it is not transmitting torque. In a first direction of rotation, the spring may slide and the freewheel may be disengaged. In second direction of rotation, the spring may be engaged and the freewheel may be engaged. A torque may be transmitted between the outer and inner elements of the bearing.

For the purposes of this application, directly interlocked refers to when an outer or inner element is one piece with a body or in contact with and/or coupled to the body. For the purposes of this application, indirectly interlocked refers to when an outer or inner element is coupled to a body by one or more interposed pieces.

In one embodiment, a spring may include an end or radial central portion interlocked in rotation with the cage. A spring may be in frictional contact with the outer and/or inner element. A spring may include coils that may interact with a cylindrical bearing surface of the outer or inner element.

In certain embodiments, a spring may include an end interlocked in rotation with an outer or inner element (e.g., an outer support or shaft). A spring may be in frictional contact

with the cage. A spring may include coils that may interact with a cylindrical bearing surface of the cage.

In one embodiment of the invention, a freewheel includes a single spring. In certain embodiments, the freewheel may include two springs. For example, one spring may be mounted between the cage and the outer element (e.g., outer support) and the other spring may be mounted between the cage and the inner element (e.g., shaft).

In some embodiments, the antifriction bearing may include an outer groove and an inner groove. Rolling elements may be positioned between outer and inner grooves. In an embodiment, at least one of the grooves may include an axial extension capable of interacting with the spring. An axial extension may include a bearing surface. In an embodiment, the bearing surface may rub against or make contact with the spring. One end of a spring may be coupled to the bearing surface. Advantageously, the cage may include an axial extension in contact with the first portion of the spring.

A spring of a freewheel may be various shapes. In one embodiment of the invention, a spring may be helical. A spring may include a rectangular section. A spring may be radially compact. A spring and a body may be a single unit.

In some embodiments, a pulley may include a freewheel bearing device and a pulley body interlocked with an outer element of the bearing. The freewheel bearing may include an antifriction bearing and a freewheel with a spring. An antifriction bearing may include a plurality of rolling elements and a cage, which may retain the rolling elements. In an embodiment, a spring may include a first end, a second end, and/or a radial central portion. A radial central portion may interact with the cage and a first and/or second end may interact with an outer and/or an inner element (e.g., outer support and/or shaft). Outer and/or inner elements may be interlocked with a body on which the rolling elements run.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the methods and apparatus of the present invention will be more fully appreciated by reference to the following detailed description of presently preferred but nonetheless illustrative embodiments in accordance with the present invention when taken in conjunction with the accompanying drawings in which:

FIG.1 depicts an embodiment of a freewheel bearing;

FIG. 2 depicts a cross-sectional view of an embodiment of a freewheel bearing;

FIG. 3 depicts an embodiment of outer and inner coils of a spring;

FIG. 4 depicts an embodiment of a freewheel bearing;

FIG. 5 depicts an embodiment of a freewheel bearing in a pulley;

FIG. 6 depicts an embodiment of a freewheel bearing device with an inner spring;

FIG. 7 depicts an embodiment of a freewheel bearing device with an outer spring;

FIG. 8 depicts an embodiment of a freewheel bearing;

FIG. 9 depicts an embodiment of a freewheel bearing;

FIG. 10 depicts an embodiment of a freewheel integrated in an antifriction bearing.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION OF EMBODIMENTS

As depicted in FIGS. 1 to 3, a freewheel bearing 1 may include an antifriction rolling bearing 2 and a freewheel 3. A freewheel 3 may be positioned between an inner element (e.g., a shaft) 4 with an axisymmetric cylindrical outer surface and an outer element (e.g., an outer support) 5 having a cylindrical bore 6. In an embodiment, a freewheel 3 may be mounted between a shaft 4 and an outer support 5.

The antifriction rolling bearing 2 may include an outer groove 7, an inner groove 8, a row of rolling elements 9, and a cage 10. A cage may retain rolling elements 9. An outer groove 7 may include an outer surface 7a positioned in a cylindrical bore 6 of an outer support 5. An outer groove 7 may include a rolling bearing channel 7b formed on its bore and/or two opposing radial transverse surfaces 7c and 7d. The inner groove 8 may include a bore 8a positioned on an outer surface of a shaft 4. A bore 8a may be coupled on an outer surface of a shaft 4. An inner groove 8 may include a rolling bearing channel 8b formed on its outer surface and two opposing radial transverse surfaces 8c and 8d. Rolling elements 9 may be balls. Rolling elements 9 may be positioned between the rolling bearing channels 7b and 8b.

In some embodiments, a cage 10 may include receptacles evenly distributed in the circumferential direction in which the rolling elements 9 are positioned. A cage 10 may include portions 11 between the receptacles and a continuous circular portion 12 on one side of the rolling elements 9 radially between the grooves 7 and 8. A cage 10 may be made of molded synthetic material, such as, but not limited to, polyamide reinforced with glass fiber.

In an embodiment, a cage 10 may include an axial extension 13 which extends beyond the radial plane as defined by the radial transverse surfaces 7c and 8c of the grooves 7 and 8. An axial extension 13 may be generally circular. An axial extension 13 may include a cylindrical outer surface 13a with a greater diameter than a diameter of a bore of the outer groove 7. An axial extension 13 may include a cylindrical bore 13b with a smaller diameter than the diameter of an outer surface of the inner groove 8. An axial length of an axial extension 13 may be similar to the axial length of a rolling bearing 2. In an embodiment, a cage 10 may be a single unit.

In some embodiments, a freewheel 3 may include a spring 14 of a substantially helical shape. A spring 14 may include a first end 15 formed of several coils. A spring 14 may include a first end 15 formed of three coils. In an embodiment, a first end 15 of a spring may contact a cylindrical bore 6 of the outer support 5. A second end 16 of a spring may include several coils. A second end 16 of a spring may include 3 coils. A second end 16 of a spring may contact an outer surface of the shaft 4. A spring may include a radial central portion 17. A radial center portion may pass through a radial notch formed or sunk into an axial extension 13, for example by overmolding. A radial central portion 17 of a spring 14 may be interlocked in rotation with an extension 13 and a cage 10.

In some embodiments, a freewheel bearing device may operate by the take-up of torque when the relative movement of the outer support 5 relative to the shaft 4 occurs in the direction of the arrow indicated in figure 2, such as when the shaft 4 is immobile and when the outer support 5 is driven in the direction of the arrow. A cage 10 of the rolling bearing may rotate at an angular speed equal to approximately half the difference of the angular speeds of the outer 7 and inner grooves 8. If an outer groove 7 of the rolling bearing moves relative to the inner groove 8 in the direction of the arrow, the cage 10 may rotate more slowly than the outer groove 7, and the result is that the outer coils of the spring 14 which are coupled to the cage 10 by its radial portion 17, may have a tendency, by friction on the cylindrical bore 6 of the outer support 5, to tighten. Simultaneously, the second end 16 of the spring 14, driven by the cage 10 may roll up and tighten on the shaft 4. The spring 14 may thus transmit torque between the outer support 5 and the shaft 4.

In some embodiments, if a radial load on the rolling elements 9 is sufficient and the torque to be transmitted is relatively weak, the torque may be transmitted between the first end 15 of the spring 14 and the shaft 4 via the cage 10 and the rolling element 9 before the inner coils of the end 16 are retightened on the shaft 4. The inner coils of the end 16 may intervene to transmit the torque if the torque increases above a certain value and causes the rolling elements 9 to slide in their rolling bearing channel 8b. In an embodiment a stiffness of the spring 14 may be selected such that the torque is not transmitted by the rolling elements 9.

If the direction of relative movement is reversed between the outer support 5 and the shaft 4, the inner coils of the second end 16 of the spring 14 may loosen and allow a relative angular movement with friction between the spring 14 and the shaft 4. The outer coils of the

first end 15 of the spring 14 may also loosen and allow a relative angular movement with friction between the spring 14 and the cylindrical bore 6 of the outer support 5. The device then may operate in freewheel mode.

Numerous variations and applications of the device may be envisioned. FIG. 4 depicts an embodiment of a freewheel bearing. The freewheel 3 may include two independent springs, an inner spring 19 and an outer spring 20. An inner spring 19 may be positioned between the bore 13b of an axial extension 13 of the cage 10 and an outer cylindrical surface of the shaft 4. An inner spring 19 may include a plurality of coils. In an embodiment an inner spring 19 may include three coils. Coils of an inner spring 19 may contact a bore of the axial extension 13. An end 21 of the inner spring 19 may be angularly interlocked with the shaft 4. An outer spring 20 may include a plurality of coils. In an embodiment, an outer spring 20 may include three coils. Coils of an outer spring 20 may contact an outer cylindrical surface 13a of an axial extension 13 of the cage 10. An end 22 of an outer spring 20 may be angularly coupled to a bore 6 of the outer support 5. For example, an end 22 of an outer spring 20 may be coupled to a bore 6 by a notch 23 formed in the bore 6 and into which an end 22 of the spring 20 protrudes.

In a first relative direction of rotation between the outer support 5 and the shaft 4, the coils of the springs 19 and 20 may contact an axial extension 13 of the cage 10 and may allow rotation without a transmission of significant torque. In a second relative direction of rotation, the springs 19 and 20 may tighten on an axial extension 13 of the cage 10 and may transmit a torque while angularly interlocking in one direction an outer support 5 with the shaft 4.

As depicted in FIG. 5, the freewheel bearing device 1 may be coupled to a pulley. The outer support 5 may form the pulley body. The outer support 5 may include an outer surface 24 in the form of trapezoidal crenellations adapted to a pulley of the poly-V type. A cylindrical bore 6 may be limited by a shoulder 25 formed at one axial end of the outer support 5 and in contact with the transverse surface 7d of the outer groove 7. The shaft may be replaced by a hub 26 with a shoulder 27 which may delimit its outer cylindrical surface and allow axial positioning of the inner groove 8 of the antifriction bearing 2. The hub 26 may include a bore 28.

FIG. 6 depicts an embodiment of a freewheel bearing device for applications in which the torque to be transmitted is relatively weak. A freewheel bearing device may not include an outer spring. A bore 6 of the outer support 5 may not include a notch. In an embodiment, a freewheel 3 for applications with low torque transmission may include a single spring. A spring may include an inner spring 19 whose free end 21 is interlocked in rotation with the shaft 4. Coils of an inner spring 19 may contact or rub a bore 13b of an axial extension 13 of the cage 10. In locking mode, coils in radial extension may be locked in the bore 13b of a radial extension 13 and therefore interlock a cage 10 with a shaft 4. The rolling elements 9 may also be interlocked with the shaft 4. An outer groove 7 may be interlocked with the outer support 5 and may remain substantially stationary relative to the shaft 4, as long as the torque to be transmitted is not too great and the radial load of the antifriction bearing 2 is sufficient. This may be a particularly economical embodiment.

FIG. 7 depicts a freewheel bearing device with a a single outer spring 20. A freewheel bearing device with a single outer spring may be economical. A single outer spring 20 may be positioned between a radial extension 13 of the cage 10 and the outer support 5.

FIG. 8 depicts an embodiment of a freewheel bearing similar to the embodiment in FIG. 1 except that the spring may not include a second end with coils. Spring 29 may include an first end 15 similar to the embodiment of the spring depicted in figure 1 and may include a radial portion 17 that faces outward and may interfere with an axial extension 13 of the cage 10. In an embodiment, an axial extension 13 may include a notch 18 extending radially outward from its bore over a portion of its radial height and disposed at its free axial end opposite the rolling elements 9. A radial portion 17 of a spring 29 may protrudes into the notch 18 and interlock in rotation. A radial portion 17 may form one end of the spring 29 with the cage 10.

In an embodiment, an economical embodiment of a freewheel bearing device may include a single spring positioned on a single side of the cage, such as the inside surface of the cage. In torque transmission mode, a first end 15 of a spring 29 may engage with a shaft 4. In a disengaged mode, coils of the first end 15 may contact a shaft 4 with slight friction. A cage 10 may then turn freely relative to the shaft 4.

FIG 9 depicts an embodiment of a freewheel bearing similar to FIG. 1. A freewheel may include a single spring 30 positioned between an axial extension 13 of the cage 10 and the outer support 5. A spring 30 may include coils which form an second end 16 similar to the embodiment depicted in FIG. 1. A spring may include a radial portion 17 protruding into a notch 18 which extends radially inward from the outer cylindrical surface 13a of the axial extension 13 of the cage 10. A radial portion may be formed at a free axial end of an axial extension 13 and opposite the rolling elements 9. The radial portion 17 positioned in the notch 18 may interlock in rotation with the cage 10 while the coils forming the second end 16 may tighten in the cylindrical bore 6 of the outer support 5 and thus may provide a transmission of torque, or, in the case of reversal of relative rotation, may rotate at the same angular speed as the cage 10 with a slight friction relative to said bore 6 of the outer support 5.

In the embodiment illustrated in FIG. 10, a freewheel 3 may be integrated in the antifriction bearing 2. For example, an outer groove 7 may include an axial extension 31 on the side of the freewheel 3 that includes radial dimensions substantially similar to the rest of the outer groove 7. The inner groove 8 may include an axial prolongation 32, which has a similar bore as the inner groove 8, and an outer cylindrical surface of a smaller diameter. For example, a diameter of an outer cylindrical surface may substantially equal the diameter of the bottom of the antifriction bearing channel 8b. A cage 10 may include an axial extension 33 with similar inner and/or outer diameters as the circular portion 12 and as the portions 11 formed between the receptacles in which the rolling elements 9 are positioned.

A spring 29, similar the embodiment illustrated in FIG. 8 but with smaller dimensions, may include a first end 15, with a plurality of coils in contact with the outer cylindrical surface of an axial prolongation 32 of the inner groove 8, and a radial portion 17, which may protrude into an axial extension 33 of the cage 10. In an embodiment, a radial portion 17 may protrude into a radial blind hole, which is not shown. A radial blind hole may be formed from the bore of the axial extension 33 and facing outward, or sunk into the material forming the axial extension 33. Thus, a spring 29 may include a first end, the radial portion 17, interlocked in rotation with the cage 10 and a second end formed by the coils of the first end 15.A second end 16 may be interlocked in rotation with the inner groove 8 in torque transmission mode. A second end may move with a slight friction relative to the outer surface of the axial prolongation 32 of the inner groove 8 in freewheel mode, in which the

outer groove 7 and the inner groove 8 move at different angular speeds. This embodiment may be extremely compact and/or may combine the functions of rolling bearing and freewheel.

In some embodiments, an embodiment of the device illustrated in FIG. 1 may include two springs such as the springs 28 and 29 of the embodiments in FIGS. 8 and 9, rather than spring 14. The embodiment of the device illustrated in FIG. 10 may be equipped with springs similar to the springs illustrated in the other embodiments, such as spring 14 depicted in FIG. 1 or springs 29, 30 depicted in FIGS. 8 and 9.

During freewheel operation, friction between coils of a spring and the corresponding friction bearing surface may be generated at a reduced relative speed arising directly from the differential angular speed between a cage of an antifriction bearing and a groove of the antifriction bearing to which the friction bearing surface is coupled. Wear of the spring by friction may be substantially reduced since the antifriction bearing cage may rotate at an angular speed equal to approximately half the difference between the angular speeds of the grooves. If N is the differential angular speed between an outer groove and an inner groove of an antifriction bearing in freewheel operation, the differential angular speed between the spring and its friction bearing surface may substantially equal N/2 according, in an embodiment, instead of N such as in the prior art. A result may be an appreciable increase in the lifetime of the system.

In this patent, certain U.S. patents, U.S. patent applications, and other materials (e.g., articles) have been incorporated by reference. The text of such U.S. patents, U.S. patent applications, and other materials is, however, only incorporated by reference to the extent that no conflict exists between such text and the other statements and drawings set forth herein. In the event of such conflict, then any such conflicting text in such incorporated by reference U.S. patents, U.S. patent applications, and other materials is specifically not incorporated by reference in this patent.

Further modifications and alternative embodiments of various aspects of the invention will be apparent to those skilled in the art in view of this description. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the general manner of carrying out the invention. It is to be understood that

the forms of the invention shown and described herein are to be taken as the presently preferred embodiments. Elements and materials may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the invention may be utilized independently, all as would be apparent to one skilled in the art after having the benefit of this description of the invention. Changes may be made in the elements described herein without departing from the spirit and scope of the invention as described in the following claims.